ATTACHMENT 2

United States Contributions to
Joint Task Group 4-9-11 on
Ku-Band Sharing Issues

INTERNATIONAL TELECOMMUNICATION UNION

RADIOCOMMUNICATION STUDY GROUPS

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TEXT FOR SECTION 3.1.2.1 OF THE CONFERENCE PREPARATORY MEETING REPORT TO WRC-2000

3.1.2 Sharing between non-GSO FSS and GSO FSS systems in the bands 10.7 - 11.7 GHz, 11.7 - 12.2 GHz (Region 2), 12.2 - 12.5 GHz (Region 3), 12.5 - 12.7 GHz (Regions 1 and 3), 12.7 - 12.75 GHz, 12.75 - 13.25 GHz, 13.75 - 14.5 GHz, 17.8 - 18.6 GHz, 19.7 - 20.2 GHz, 27.5 - 28.6 GHz and 29.5-30.0 GHz

3.1.2.1 Protection of the GSO FSS systems

Resolution 130 (WRC-97) introduced provisional $EPFD_{down}$ and APFD ($EPFD_{up}$) limits for non-GSO FSS systems in certain bands intended to protect GSO FSS systems operating co-frequency and requested ITU-R to conduct the appropriate technical, operational and regulatory studies to review the regulatory conditions relating to the coexistence of non-GSO and GSO systems in the FSS. Joint Task Group 4-9-11 was assigned the responsibility for reporting the results of those studies to CPM-99.

The provisional single entry $EPFD_{down}$ limits are intended to protect GSO FSS receiving earth stations from transmitting satellites in a non-GSO FSS system. The provisional single entry $EPFD_{up}$ limit is intended to protect the GSO FSS receiving satellite from transmitting earth stations in a non-GSO FSS system. It has been agreed that curves of EPFD as a function of time, i.e. masks, should be used for the $EPFD_{down}$ limits, rather than discrete points as adopted by WRC-97. It has also been agreed that in order to adequately protect GSO FSS networks it is necessary to define an aggregate interference limit from all non-GSO systems and that the aggregate limit must not be exceeded (see section 3.1.2.4). ITU-R identified an interference case that was not completely addressed by WRC-97. This is the case of interference from transmissions of satellites in a non-GSO FSS system to GSO receive space stations. Accordingly, ITU-R developed a new parameter, $EPFD_{is}$, for the frequency bands for which the provisional $EPFD_{down}$ limits exist in Article S22 and which are also allocated to the GSO FSS in the Earth-to-space direction.

ITU-R has agreed that several mitigation techniques are available to reduce potential interference from non-GSO systems into GSO FSS systems. These techniques may be considered by non-GSO systems in order to operate within the EPFD masks.

3.1.2.1.1 Characteristics of the GSO FSS

Circular Letters CR/92 and CR/116 invited administrations and Sector Members to supply data on existing and planned GSO FSS links in certain frequency bands. The parameters for over 600 14/11 GHz and over 200 30/20 GHz carriers were collected in a database. Descriptions of GSO

FSS systems are contained in Recommendation S.1328. In addition to traditional fixed margin systems, i.e. systems that use power to compensate for rain fade, which are included in the database for the 14/11 GHz and 30/20 GHz bands, GSO FSS systems employing adaptive coding to compensate for rain fade are also included for the 30/20 GHz band.

For fixed margin systems, the more sensitive links include those operating with larger earth station antennas, in low rain regions and/or at high altitudes with little or no excess margin. Low rain zone areas where there are expected to be a large number of sensitive links include North Africa, Canada, Eastern China, the Middle East, and the Western United States. Excess margin is margin above what a link needs to meet its short-term performance objective due to rain. Excess margin is expected to be minimal for commercial GSO transponders, because the operator utilizes any additional power to increase the system capacity and provide additional carriers or higher data rates. In the revision to Recommendation ITU-R S.1323, it was agreed that the system designer and operator should have control over the overall performance of a network and have the capability to provide the required quality of service. Inclusion of an additional link margin above that necessary to compensate for rain fading, e.g. to compensate for equipment ageing, is not to be considered as part of the protection from interference by other networks.

Systems that employ adaptive downlink coding provide link robustness to rain fades on a per link basis. The excess margin concept does not apply to adaptive coding systems. Adaptive coding systems set aside a per cent of each beam's channel capacity in reserve as "spare capacity" (similar to rain margin in fixed margin systems) that is used to transmit additional bits/s for links requiring "heavy coding" to compensate for rain. The "spare capacity" is sized to cope with the expected rain statistics for a specified availability on a per beam basis as is the power margin in fixed power link systems. This allows constant user data throughput by employing heavy code on a link-by-link basis depending on the link conditions at each user terminal. The "spare capacity" concept applies to all downlink adaptive coding systems because it applies to information throughput capacity and does not depend on the specifics of the coding design.

Circular Letter CR/115 requested administrations and Sector Members to provide information on the number, locations and principal characteristics of their current and planned earth station antennas having a receive gain greater than 60 dBi, in order to assess the scope and specifics of a coordination procedure. Several administrations and Sector Members responded to CR/115, providing data at varying levels of detail on approximately 400 large antennas. Most of the large GSO earth station antennas identified in response to CR/115 are in the 14/11 GHz band. There were few large antennas identified in response to CR/115 in the 30/20 GHz band.

For the characteristics of the GSO earth station reference antenna pattern for calculating $EPFD_{down}$ limits and for conducting interference assessments to GSO networks from non-GSO FSS systems, ITU-R agreed to adopt patterns specified in WP 4 DNR [Document 4A/TEMP/172]. These reference antenna patterns are defined in two dimensions only, but it was decided that they would be considered as applicable throughout all rotational planes. Reference patterns were defined to cover both co- and cross-polar signals. These reference patterns differ from those currently referenced in the definitions of $EPFD_{down}$ in Article S22, which are based upon worst-case peak envelope patterns and thus these new patterns facilitate the ability of the non-GSO system to meet the $EPFD_{down}$ limits.

3.1.2.1.2 Protection criteria

ITU-R agreed to use the criteria defined in Recommendation S.1323 for the maximum permissible levels of interference in a satellite network in the FSS caused by other co-directional networks below 30 GHz.

For fixed margin system links, Recommendation S.1323 allows the aggregate interference from non-GSO systems to GSO FSS networks to be responsible for 10 per cent of the unavailability time in a GSO network and/or time allowances specified in the performance objectives of the GSO network. There was an agreed upon method to handle cases where the GSO link exceeds or fails to meet its target availability. [JTG 168]

An additional criterion identified in S.1323 is protection of GSO FSS networks from loss of synchronization. However, no agreement was reached on defining this criterion. Based on measurements for sync-loss thresholds for systems with data rates less than 34 Mbits/sec contributed to ITU-R (Document 4A/TEMP/181), ITU-R agreed that the following sync-loss thresholds need to be considered when determining 100 per cent not to exceeded EPFD limits:

Modulation and Coding	**C/(N+I) (dB)**
QPSK rate 7/8	6.0
QPSK rate 3/4	5.3
QPSK rate 1/2	3.5
8-PSK	8.1
16-QAM	11.0

Recommendation S.1323 also addresses the protection criteria for GSO FSS systems employing adaptive coding. Adaptive coding systems are planned in the 30/20 GHz band but not in the 14/11 GHz band. These criteria define the impact from all non-GSO FSS systems on a per beam basis versus a per link basis for fixed link margin systems. It allows the aggregate interference from non-GSO systems to be responsible for a 10 per cent decrease in the amount of spare capacity available to adaptive coding links that require heavy coding.

3.1.2.1.3 Methodologies used to assess the adequacy of the limits to protect GSO FSS networks

3.1.2.1.3.1 $EPFD_{up}$ and $EPFD_{is}$

In order to more accurately define the interference level from co-frequency non-GSO FSS systems into receive GSO satellite antennas, ITU-R agreed that the definition of APFD should be modified to Equivalent Power Flux-Density $(EPFD)_{up}$ to take account of the GSO satellite antenna directivity. This would require that the equation for the definition of APFD be modified to incorporate the GSO satellite receive antenna directivity. The same definition would be used to define $EPFD_{is}$. The new equation is given in DNR [Document 4-9-11/371].

3.1.2.1.3.2 $EPFD_{down}$

ITU-R agreed that in deriving candidate EPFD limits, different methodologies can be used. Recommendation S.1323 describes several methodologies to derive and assess the $EPFD_{down}$ limits (e.g. Methodologies A, B). ITU-R agreed that the detailed convolution of fading and interference degradation (e.g. Procedure D in Recommendation S.1323) should be used to evaluate the impact of

candidate $EPFD_{down}$ masks on GSO FSS fixed-link margin systems. ITU-R agreed that excess GSO FSS margins should not be used when developing EPFD limits.

For 30/20 GHz adaptive coding GSO FSS systems, a study provided a methodology, which provides results that can be compared with the criteria in Recommendation S.1323.

3.1.2.1.3.3 Conversion of aggregate EPFD mask to single entry EPFD mask

The criteria to protect GSO FSS systems from non-GSO FSS systems are based on aggregate interference from all non-GSO FSS systems. ITU-R agreed that an equivalent number "N_{eff}" of non-GSO FSS systems equal to 3.5 will be used to convert the aggregate EPFD limits to single entry $EPFD_{down}$ limits. The methodology to convert from aggregate to single entry is described in section 3.1.1. The number of co-frequency, co-coverage non-GSO FSS systems filed for at ITU exceeds 3.5. It has been agreed that to adequately protect GSO FSS networks, it is necessary to also agree on an aggregate $EPFD_{down}$ limit that must not be exceeded. A regulatory mechanism that would allow the actual number of non-GSO FSS systems to exceed the number used to derive single-entry limits from the aggregate $EPFD_{down}$ limits, while not exceeding the aggregate $EPFD_{down}$ limit itself, needs to be developed as described in section 3.1.1.3.

3.1.2.1.4 Results of studies relating to the review/revision of the provisional power limits appearing in Section II of Article S22

3.1.2.1.4.1 $EPFD_{up}$ and $EPFD_{is}$

Several studies were provided on the protection of GSO FSS receive space stations from transmitting non-GSO FSS earth stations in a non-GSO system ($EPFD_{up}$) and on protection of GSO FSS receive space stations from transmitting space stations in a non-GSO FSS system ($EPFD_{is}$). As agreed, the $EPFD_{up}$ and $EPFD_{is}$ definitions should include the directivity of the GSO FSS space station antenna, which required specifying a reference antenna radiation pattern and beamwidth. This provides a more accurate assessment of the non-GSO interference at the GSO space station and allows non-GSO FSS systems to meet the required $EPFD_{up}$ and $EPFD_{is}$ more easily.

For the characteristics of the GSO spacecraft reference antenna pattern for calculating $EPFD_{up}$, ITU-R agreed to adopt the use of the antenna pattern in ITU-R Recommendation S.672 with a gain of 32.4 dBi, a side-lobe level of -20 dB, and a beamwidth of 4° for the 14/11 GHz band and with a gain of 40.7 dBi, a side-lobe level of -10 dB (an exception to Recommendation S.672) and a beamwidth of 1.55° for the 30/20 GHz band.

ITU-R agreed on the following $EPFD_{up}$ and $EPFD_{is}$ limits in the 14/11 GHz and 30/20 GHz bands with associated reference antenna beamwidth and radiation pattern.

TABLE 3.1.2-1

$EPFD_{up}$ limits

Frequency band (GHz)	$EPFD_{up}$ dB(W/m^2)	Percentage of time aggregate level may not be exceeded	Reference bandwidth (kHz)	Reference antenna beamwidth and reference radiation pattern
12.50 - 12.75 12.75 - 13.25 13.75 - 14.5	-160	100	40	4 degrees ITU-R S.672, Ls = -20
17.3 - 17.8 (Regions 1 and 3) 17.8 - 18.1 (Region 2)	[-153]	100	40	4 degrees ITU-R S.672, Ls = -20
27.5 - 28.6	-148	100	1 000	1.55 degrees ITU-R S.672, Ls = -10[1]
29.5 - 30.0	-148	100	1 000	1.55 degrees ITU-R S.672, Ls = -10[1]
[1] In the equations in Recommendation ITU-R S.672, the same values of the a and b parameters as used with Ls = -20 should be used.				

TABLE 3.1.2-2

$EPFD_{is}$ Limits

Frequency band (GHz)	$EPFD_{is}$ dB(W/m^2)	Percentage of time aggregate level may not be exceeded	Reference bandwidth (kHz)	Reference antenna beamwidth and reference radiation pattern
10.7 - 11.7 (Region 1) 12.5 - 12.75 (Region 1) 12.7 - 12.75 (Region 2)	-160	100	40	4 degrees ITU-R S.672, Ls = -20
17.8 - 18.4	[-153]	100	40	4 degrees ITU-R S.672, Ls = -20

Consideration of the possible use of the band 18.1 - 18.4 GHz (Earth-so-space) by non-GSO FSS systems is addressed in section 3.2.

3.1.2.1.4.2 $EPFD_{down}$

As stated in the revision to Recommendation ITU-R S.1323, many different mask shapes may produce results that are acceptable and meet the required criteria. Thus it is important when developing masks that this be given consideration. Studies have shown that different non-GSO systems produce significantly different $EPFD_{down}$ interference characteristics. Some non-GSO networks that have been proposed produce both long-term and short-term interference, while other

non-GSO networks produce solely long-term interference. It is preferable to aim for a single $EPFD_{down}$ mask that will allow the performance requirements of GSO links to be met without constraining either type of non-GSO FSS system to an unacceptable level. However, to protect GSO FSS systems and accommodate non-GSO FSS systems with different technical characteristics, two $EPFD_{down}$ masks may be required for each GSO antenna size.

Studies have demonstrated that the provisional $EPFD_{down}$ limits do not protect certain GSO FSS links in accordance with the 10 per cent criterion in S.1323; in addition, synchronization loss had not been considered as a criterion for determining the provisional limits. New limits were developed by analysing CR/92, CR/116 links. It was agreed that the CR/92, CR/116 links do not represent the extent, number or type of sensitive links that may occur in actual practice, or their collective significance to the GSO FSS networks. The number of sensitive links is thus not necessarily in proportion with their importance to the GSO FSS service being provided or planned to be provided by particular networks. Therefore the proportion of links that pass or fail the protection criteria is not an indication of the overall protection of the GSO FSS service.

a) 14/11 GHz band

ITU-R agreed to develop $EPFD_{down}$ masks for earth station antenna sizes of 0.6 m, 1.2 m, 3 m and 10 m in a 40 kHz reference bandwidth. WP 4A concluded that the $EPFD_{down}$ masks developed for 10 m antennas in the 11/14 GHz bands would also protect larger antennas, however protection of large earth station antennas (approximately 10 m to less than 16 m) was not fully studied by ITU-R. The specific case of very large antennas (16 m or greater) is addressed in section 3.1.2.1.4.3.

ITU-R agreed on an aggregate $EPFD_{down}$ mask that adequately protects GSO FSS systems using 60 cm and 1.2 m antenna sizes. These masks are shown in Figures 3.1.2-1 and -2 below.

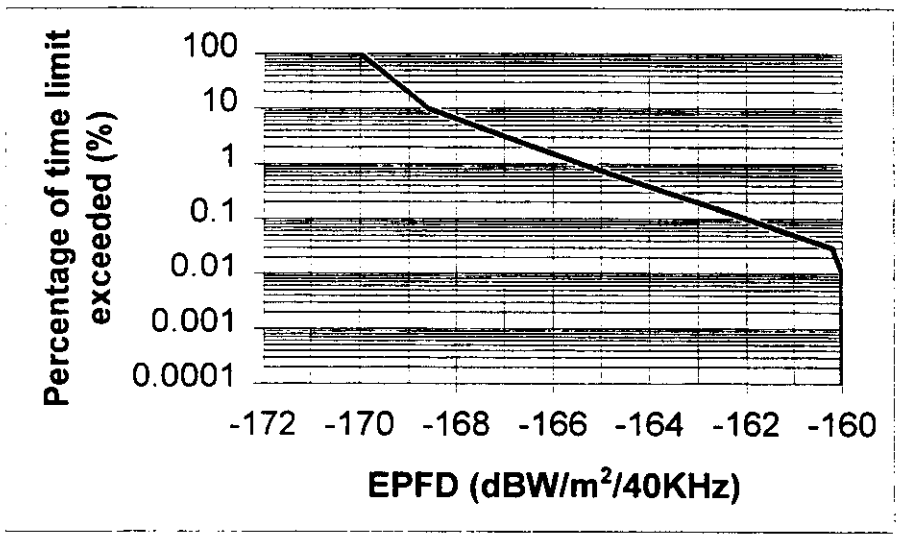

FIGURE 3.1.2-1

Aggregate $EPFD_{down}$ mask for 0.6 metre GSO earth station antennas

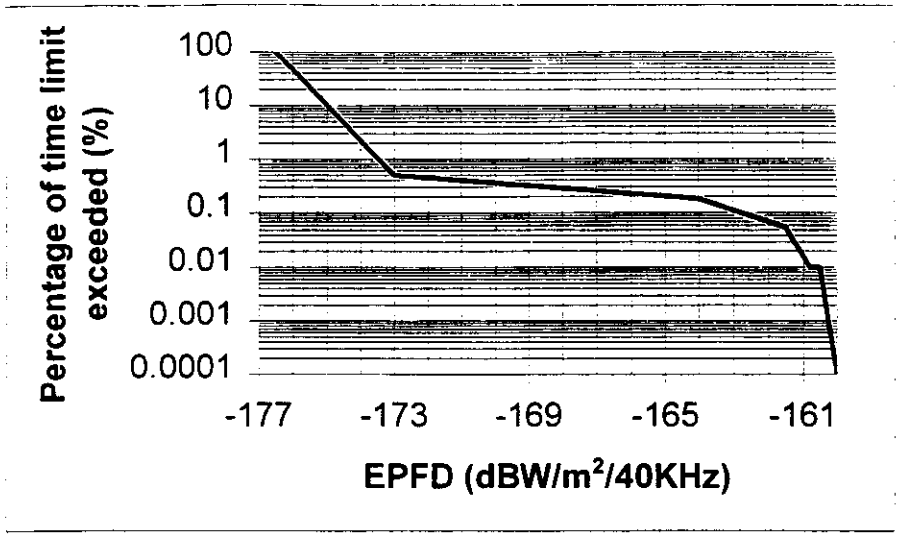

FIGURE 3.1.2-2

Aggregate $EPFD_{down}$ mask for 1.2 metre GSO earth station antennas

For the 60 cm and 1.2 m earth station antenna sizes synchronization loss was not a problem. However studies showed that synchronization loss could occur with an EPFD level of -162 dB(W/m^2/40 kHz) for a 3 m earth station antenna and an EPFD level of -166 dB(W/m^2/40 kHz) for a 10 m earth station antenna. For the 3 m and 10 m GSO earth station antenna sizes two masks were developed, per antenna size, as shown in Figures 3.1.2-3 and -4 respectively. The mask denoted by the solid line protects a larger percentage of the GSO FSS links, in accordance with the 10 per cent criterion and from sync loss, but still does not protect all links. It was designed to protect a substantial number of links in Rain Zones C to E as these rain zones have large populations. The mask denoted by the dashed line protects fewer of the GSO FSS links but can more easily accommodate non-GSO FSS systems.

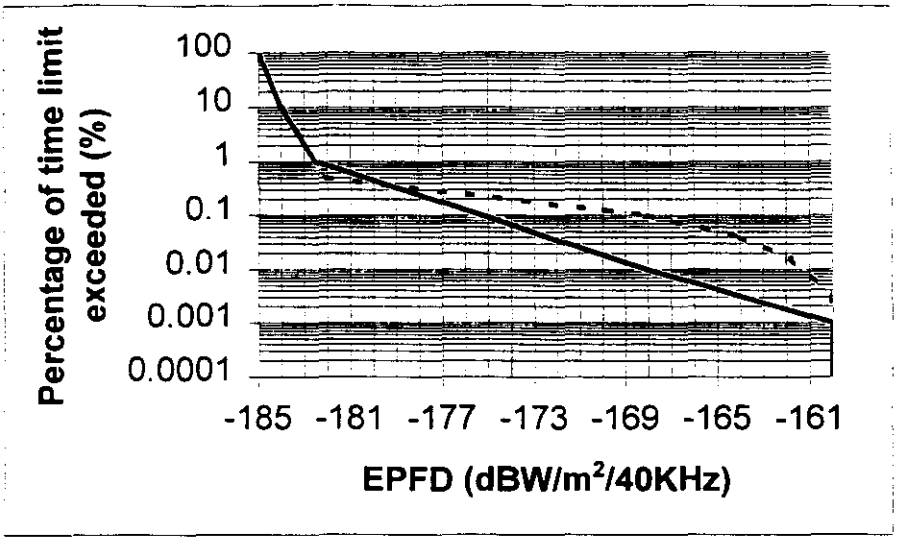

FIGURE 3.1.2-3

Aggregate $EPFD_{down}$ masks for 3 metre GSO earth station antennas

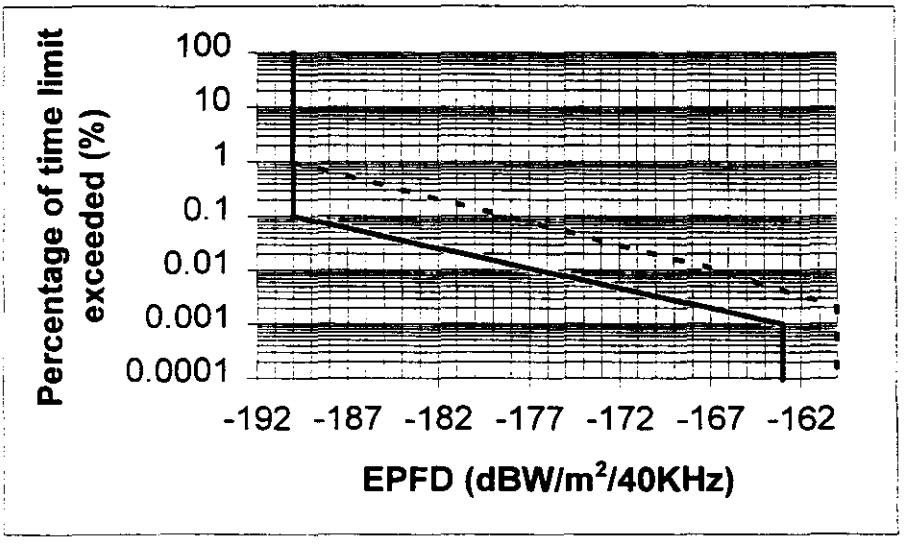

FIGURE 3.1.2-4

Aggregate $EPFD_{down}$ masks for 10 metre GSO earth station antennas

For the 3 m antenna, the different protection levels provided by the two masks are demonstrated in Figures 3.1.2.-5 and -6 below.

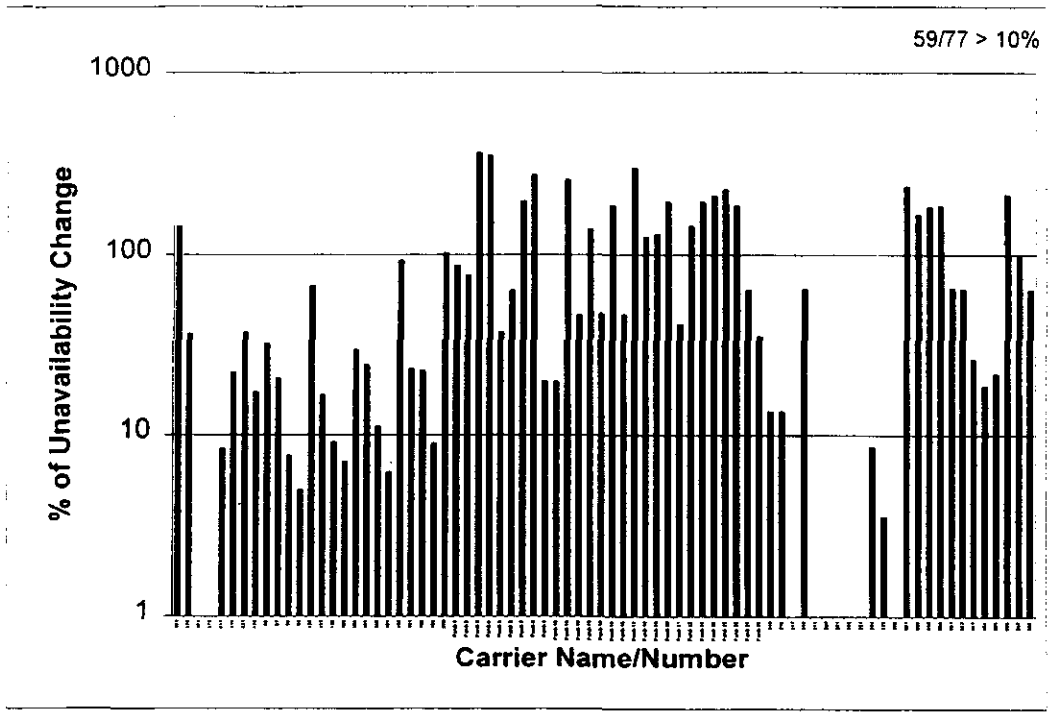

FIGURE 3.1.2-5

Protection levels for 3 metre GSO antennas from dashed-line mask

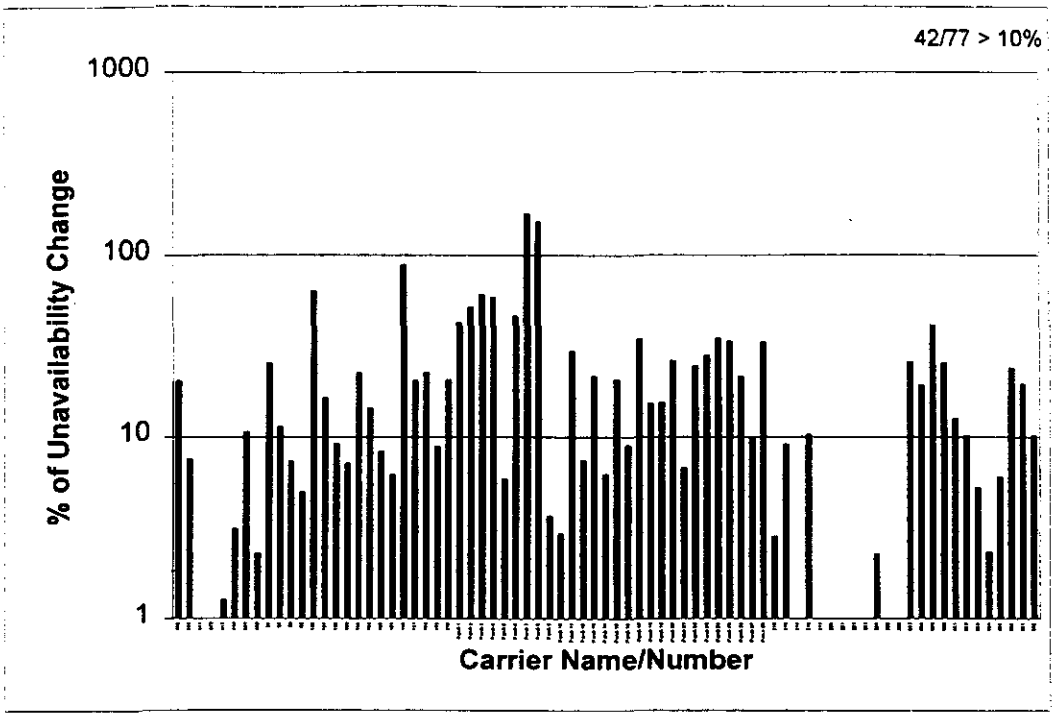

FIGURE 3.1.2-6

Protection levels for 3 metre GSO antennas from solid-line mask

As shown, neither of the masks developed for either the 3 m or 10 m antenna size fully protect GSO links from synchronization loss. Recognizing this, it was agreed to examine an approach of adopting two $EPFD_{down}$ limits, one operational and the other for software validation (see section 3.1.2.4). This approach will allow affected earth stations to seek additional protection from an affecting non-GSO operator. For such an approach the suitable 0 per cent-of-time $EPFD_{down}$ limits (i.e. levels not to be exceeded for 100 per cent of time) are -170 dB(W/m^2/4 kHz) (-160 dB(W/m^2/40 kHz)) for the validation limit and -173 dB(W/m^2/4 kHz) (-163 dB(W/m^2/40 kHz)) for the operational limit for GSO FSS earth stations having receive antenna gain of 59 dBi or more (approximately 9 metres or more), excluding the case of very large antennas. Analyses have shown that with a -160 dB(W/m^2/40 kHz) $EPFD_{down}$ limit sever degradations including synchronization loss can occur to GSO earth stations with antenna sizes of 3 metres or greater. Therefore operational limits are also needed to protect antenna diameters of 3 metres and above. Analyses have shown that an operational limit of -173 dB(W/m^2/4 kHz) would protect the majority of earth stations having antennas of 3 metres and larger.

b) 30/20 GHz band

The 30/20 GHz band has been divided into two segments. The upper band is 19.7 - 20.2 GHz and the lower band is 17.8 - 18.6 GHz. The specific case of very large antennas is addressed in section 3.1.2.1.4.3.

Upper band (19.7 - 20.2 GHz)

ITU-R agreed that $EFPD_{down}$ masks should be specified for antenna sizes of 70 cm, 90 cm and 2.5 m for the 19.7 - 20.2 GHz band in reference bandwidths of 1 MHz and 40 kHz. For earth station antennas up to 3.5 m, it was agreed that the 2.5 m mask would provide relatively adequate protection. For earth stations larger than 3.5 m, it was agreed to use the procedure described in section 3.1.2.4 with an operational $EFPD_{down}$ level of -157 dB(W/m^2/40 kHz).

For the 70 cm and 2.5 m antenna sizes two aggregate masks, per antenna size, were developed as shown in Figures 3.1.2-7 and -8 respectively. The masks denoted Curve A were developed through the use of Recommendation S.1323, consideration of synchronization loss, adequate protection of most GSO FSS links and negotiations between GSO FSS and non-GSO FSS operators. While the masks denoted Curve B were developed by accommodating one non-GSO FSS system and applying Recommendation S.1323, this resulted in protection of a fewer number of GSO FSS links.

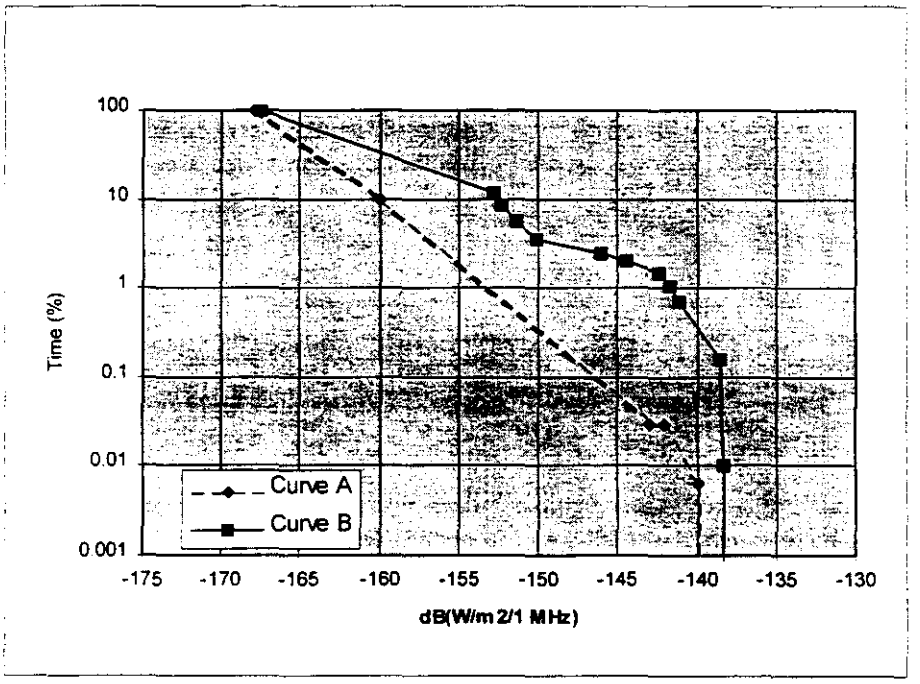

FIGURE 3.1.2-7

Aggregate $EPFD_{down}$ masks developed for 70 cm GSO earth station antennas

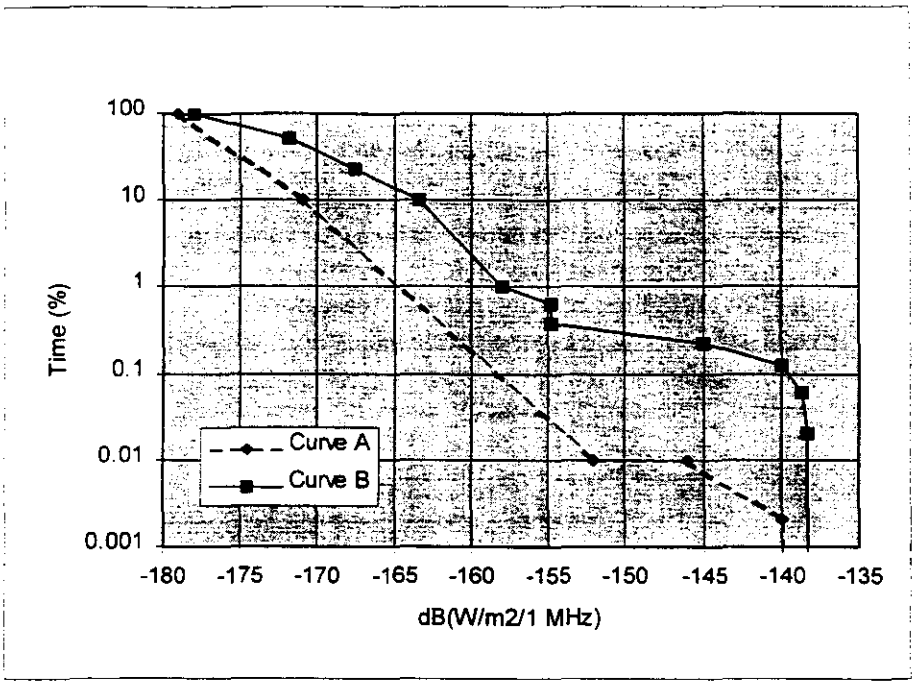

FIGURE 3.1.2-8

Aggregate $EPFD_{down}$ masks developed for 2.5 m GSO earth station antennas

ITU-R agreed that adaptive coding systems should be protected from non-GSO systems. Studies have shown that the impact of non-GSO FSS interference on adaptive coding GSO FSS systems is greater from MEO non-GSO systems than from LEO non-GSO systems (i.e. MEO systems at the same $EPFD_{down}$ level affect a larger per cent of the GSO beam). As a result, for the 90 cm antenna size, two aggregate $EPFD_{down}$ masks are required, one for LEO non-GSO systems (altitudes of 7 000 km or less) and the other for MEO non-GSO systems (altitudes greater than 7 000 km). Figure 3.1.2-9 shows the masks developed for the 90 cm antenna size. The masks denoted by Curves A and B were developed recognizing the need to protect adaptive coding systems. Curve A applies to the LEO non-GSO systems and Curve B applies MEO non-GSO systems. Curve A was developed through the use of Recommendation S.1323, consideration of synchronization loss, adequate protection of most GSO FSS links and negotiations between GSO FSS and non-GSO FSS operators. Curve B was developed using the criteria in Recommendation S.1323, adequate protection of GSO FSS links and negotiations between GSO FSS and non-GSO FSS operators. The mask denoted by Curve C was developed by accommodating one non-GSO FSS system and applying Recommendation S.1323. This resulted in protection of a fewer number of fixed margin GSO FSS links. Curve C did not address protection of adaptive coding GSO FSS systems.

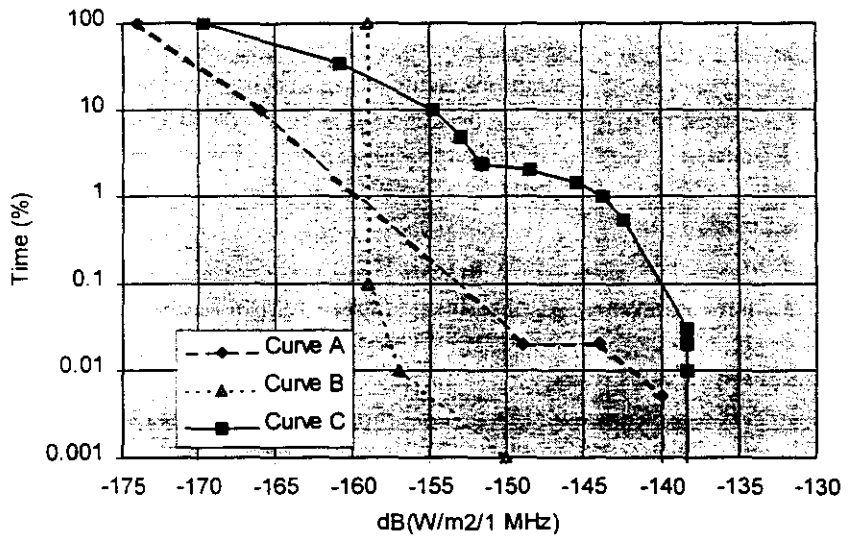

FIGURE 3.1.2-9

Aggregate $EPFD_{down}$ masks developed for 90 cm GSO earth station antennas

Although the adoption of one mask may be simpler, if only one $EPFD_{down}$ mask is to be adopted it would have to be the more stringent mask that protects adaptive coding GSO FSS systems from MEO non-GSO systems. This, however, would unnecessarily constrain LEO non-GSO FSS systems that can meet the protection criteria with a more relaxed $EPFD_{down}$ mask. There was a proposal for a 0 per cent-of-time "operational" MEO $EPFD_{down}$ level of -157 dB(W/m^2/40 kHz), applicable to 0.9 m antennas as an alternative to having two $EPFD_{down}$ masks. However this level was not considered to be sufficient to adequately protect adaptive coding systems from MEO interference and therefore could not be agreed to.

Lower band (17. 8 - 18.6 GHz)

It has been agreed that larger (3.5 - 5 m) GSO earth station antennas will be accommodated in this band. Because it is more difficult to accommodate non-GSO FSS systems and protect GSO FSS links with larger earth station antennas, no agreement was reached on $EPFD_{down}$ masks for this band. The range of $EPFD_{down}$ masks developed are shown in Document 4A/TEMP/XX.

3.1.2.1.4.3 Very large earth stations

ITU-R agreed that downlink transmissions to very large GSO earth station antennas are very sensitive to interference. This sensitivity is more related to the availability degradation than to the potential for synchronization loss (i.e. the 100 per cent $EPFD_{down}$ value). GSO networks with very large earth station antennas have unique characteristics that make them more sensitive to

interference from non-GSO systems[1]. ITU-R agreed that transmissions to earth stations with very large antennas need to be protected and thus it may be desirable that they be treated separately from other GSO networks. A coordination procedure would be one possible mechanism to ensure this protection. ITU-R has selected 64 dBi in the band 10.7 - 12.75 GHz and 68 dBi in the bands 17.8 - 18.6 GHz and 19.7 - 20.2 GHz as the GSO earth station receive antenna gain above which hard limits may be replaced by some form of coordination procedure. These gain thresholds correspond to an antenna diameter of approximately 16 metres or greater, with most antennas being 18 metres or larger. Based on the responses to CR/115, ITU-R agreed that setting the threshold size of very large GSO earth station antennas at 64 dBi in the band 10.7 - 12.75 GHz and 68 dBi for the bands 17.8 - 18.6 GHz and 19.7 - 20.2 GHz clearly indicates that there would be few cases requiring coordination.

For GSO FSS networks with very large earth station antennas the protection criteria are defined by the performance characteristics of these systems. ITU-R concluded that coordination would be triggered for GSO FSS networks having very large earth station antennas meeting all of the following conditions:

a) Earth station antenna maximum isotropic gain (APS4/II-3C10c2) of 64 dBi or higher for the band 10.7 - 12.75 GHz and 68 dBi or higher for the bands 17.8 - 18.6 GHz and 19.7 - 20.2 GHz.

b) G/T of 44 or higher, where G is earth station antenna maximum isotropic gain and T_l (APS4/II-4a1) is the lowest equivalent satellite link noise temperature which includes the earth station noise temperature, retransmitted uplink noise, cross-polarization noise, inter-modulation noise and any other internal link noise sources. The link noise temperature as defined herein excludes external noise sources.

c) Space station emission bandwidth (APS4/II-3C7a) of 250 MHz or higher for the band 10.7 - 12.75 GHz and 800 MHz or higher for the bands 17.8 - 18.6 GHz and 19.7 - 20.2 GHz.

In addition to these conditions, ITU-R agreed that the coordination trigger for very large earth station antennas should contain the condition of the $EPFD_{down}$ level radiated by the non-GSO FSS system into the earth station employing the very large antenna considered when this earth station is pointed to the wanted GSO satellite. The proposed aggregate $EPFD_{down}$ level and associated percentages of time for the band 10.7 - 12.75 GHz are -206.4 dB(W/m^2/4 kHz) for 99.999 per cent of the time and -179 dB(W/m^2/4 kHz) for 100 per cent of the time. The proposed aggregate $EPFD_{down}$ level and associated percentages of time for the bands 17.8 - 18.6 GHz and 19.7 - 20.2 GHz are -179 dB(W/m^2/MHz) for 99.999 per cent of the time and -143 dB(W/m^2/MHz) for 100 per cent of the time. The mask shown in Figure 3.1.2-10 was determined to meet the performance criteria for a 20 metre antenna in the bands 17.8 - 18.6 GHz and 19.7 - 20.2 GHz according to Procedure D in Recommendation S.1323.

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[1] GSO networks with very large earth station antennas are more sensitive to non-GSO interference because of their unique characteristics such as: service availability above 99.95 per cent in many ITU rain zones; required Eb/No values on the order of 10 dB; greater sensitivity to loss of synchronization; single carrier per polarization per downlink beam, preventing use of techniques for reallocation of downlink power among multiple destinations and/or multiple carriers and some have wideband downlinks overlapping multiple band segments that have provisional $EPFD_{down}$ limits.

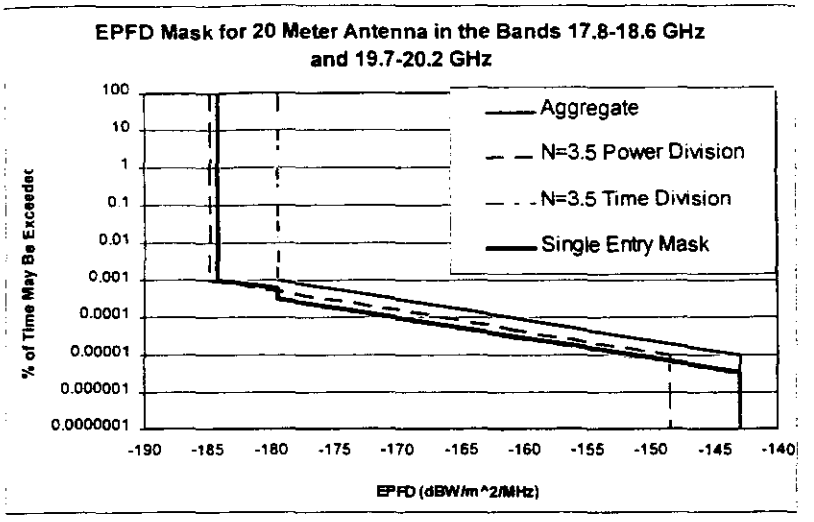

FIGURE 3.1.2-10

Aggregate $EPFD_{down}$ masks required for 20 m GSO earth station antennas

3.1.2.1.4.4 GSO inclined orbits

Studies were conducted by ITU-R to determine the value of inclination at which GSO networks would begin to experience degradation in protection from $EPFD_{down}$ levels and are equally protected by the 10° GSO arc avoidance mitigation technique. ITU-R agreed that at 2.5° inclination, the impact to the short-term $EPFD_{down}$ is marginal compared to a GSO network with 0° inclination for dishes 0.7 m or larger. ITU-R agreed that the $EPFD_{down}$ masks adopted for the protection of non-inclined GSO links would also protect links using satellites in slightly inclined orbits up to 2.5° inclination. However, where an operator can demonstrate that the actual inclination of an in-service GSO satellite has exceeded 2.5°, the operator should have recourse to a regulatory procedure to resolve any problems of interference exceeding the relevant $EPFD_{down}$ mask.

3.1.2.1.4.5 GSO TT&C

ITU-R agreed that TT&C carriers transmitted to geostationary satellites in the FSS in normal mode of operation may exceed the off-axis e.i.r.p. levels given in Article S22 by up to 16 dB in the frequency bands 12.75 - 13.25 and 13.75 - 14.5 GHz. ITU-R agreed that for all other modes of operation TT&C carriers transmitted to geostationary satellites in the FSS are exempted from the off-axis e.i.r.p. levels given in Article S22. To protect GSO TT&C carriers and not unduly constrain the design of non-GSO systems it may be useful to locate GSO TT&C carriers in specific portions of the service band. Non-GSO systems would then avoid operating in this part of the band. Further study is needed on this subject.

3.1.2.1.4.6 Validation software

ITU-R agreed that the software tool currently being developed for use by BR for validating non-GSO FSS systems compliance with the EPFD limits is based on worst-case interference analysis. Consideration was given to the possibility of making BR software more realistic such that the non-GSO FSS systems could comply with tighter EPFD masks. Further study is needed on this subject.

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DRAFT ELEMENT OF CPM TEXT FOR SECTION 3.1.1

SHARING AMONG NON-GSO FSS SYSTEMS AND AGGREGATION OF INTERFERENCE FROM MULTIPLE NON-GSO FSS SYSTEMS INTO GSO NETWORKS

3.1.1.1a Results of studies relating to sharing among co-frequency non-GSO FSS systems in the 14/11 and 30/20 GHz bands included in Resolution 130

Several studies contributed to ITU-R addressed the determination of the number of non-GSO FSS systems that can share co-frequency in the 14/11 and 30/20 GHz bands included in Resolution 130 (WRC-97). These studies have shown the following:

- that there are several mitigation techniques that should be considered for use to achieve satisfactory sharing between co-frequency, codirectional non-GSO FSS satellite networks in Resolution 130 (WRC-97) frequency bands as shown in draft new Recommendation (Document 4A/TEMP/123);
- that an important factor to be taken into account in the determination of the number of non-GSO FSS systems that can share with each other is potentially acceptable levels of interference along with the corresponding avoidance angles necessary to achieve these levels (draft revision to Recommendation ITU-R S.1323 (4A/TEMP/154) can give guidance for determining interference criteria for non-GSO FSS systems);
- that non-GSO FSS systems that are required to operate with large avoidance angles (around 10 to 12 degrees) in order to share with other non-GSO FSS systems will result in a limit on the number of systems that can share due to the reduction in capacity and the potential increase in outages or coverage degradation;
- that some non-GSO FSS systems may be able to use smaller avoidance angles (about 3 to 7 degrees) to share with other non-GSO FSS systems, thus resulting in an increase in the number of systems that can share a given frequency band.

3.1.1.1b Studies on the aggregation of interference from multiple non-GSO FSS systems into GSO networks

Studies were also performed to determine the manner in which interference from multiple non-GSO FSS systems aggregates into a GSO FSS earth station. These studies resulted in a method to convert any $EPFD_{down}$ versus %-of-time curve required to protect GSO downlinks from the aggregate interference from multiple non-GSO FSS systems to the corresponding $EPFD_{down}$ versus %-of-time curve for interference from a single non-GSO FSS system.

These studies also showed that the aggregate interference into a GSO network from N non-GSO FSS systems sharing a frequency band will likely be different than the interference into a GSO network caused by one non-GSO FSS system multiplied by a factor of N (in either power level or time percentage) since the impact of each non-GSO FSS system will not be identical.

3.1.1.2 Methods to satisfy the agenda item

Taking account of the studies leading to assessments of the maximum number of non-GSO FSS systems which are likely to be able to share frequencies, a value of 3.5 for $N_{effective}$ was agreed as a compromise to be used to determine the final values of single-entry $EPFD_{down}$ versus percentage of time to be applied in bands currently covered under Resolution 130 (WRC-97). This value is to be used solely for the purpose of deriving single-entry EPFD masks from aggregate EPFD masks and is not a representation of the actual number of non-GSO FSS systems that can share a given frequency band.

For converting from aggregate $EPFD_{down}$ masks to single-entry $EPFD_{down}$ masks, the following method should be used:

- The aggregate mask is drawn using a linear abscissa scale for the EPFD in decibel units increasing to the right, and a logarithmic scale for percentage of time increasing upwards. A second line is then drawn, $10*\log_{10}(N_{effective})$ dB to the left of the first line, thus representing power division. A third line is then drawn, below the first line by a factor of $N_{effective}$, thus representing time division.
- For GSO earth stations smaller than approximately 10 metres in the 10.7 - 12.75 GHz band and smaller than [5] metres in the 17.8 - 18.6 and 19.7 - 20.2 GHz band, the single-entry mask is then formed by taking the second line from 100%-of-time to the point where it crosses the third line. The third line is then followed to the 0%-of-time point. In cases where the time division curve (second line) and power division curve (third line) do not cross, follow the power division curve (second line) from 100% to 0.03% then remain constant in per cent time until intersection with the time division curve (third line), then follow the time division curve (third line) for the remaining percentages of time.
- In the case of antennas greater than or equal to approximately 10 metres in the 10.7 - 12.75 GHz band and [5] metres in the 17.8 - 18.6 and 19.7 - 20.2 GHz bands, the single-entry mask is formed by taking the second line from 100%-of-time to the point where it crosses the third line, the third line between that point and the point where the third line reaches 0.01%-of-time, and the first (i.e. aggregate) line for percentages of time below 0.001%. The single-entry mask is completed by drawing a straight line between the 0.01%-of-time EPFD and the 0.001%-of-time EPFD. In cases where the time division curve (second line) and power division curve (third line) do not cross, follow the power division curve (second line) from 100% to 0.03% then remain constant in per cent time until intersection with the time division curve (third line), then follow the third line until it reaches 0.01%-of-time. The mask is completed by drawing a straight line between the 0.01%-of-time EPFD and the 0.001%-of-time EPFD.

3.1.1.3 Regulatory and procedural considerations

There is a need to provide a regulatory mechanism that would ensure i) that the agreed upon aggregate interference levels needed to protect geostationary FSS and BSS systems from non-geostationary FSS systems under the Resolutions 130/538 approach are never exceeded; and ii) to provide a mechanism for processing publication, coordination, and notification materials from non-geostationary FSS systems, even when there are more potential systems than the number

on which the $EPFD_{Down}$, $EPFD_{Up}$, and $EPFD_{IS}$ limits were based. One possible mechanism for meeting these objectives is a WRC-2000 Resolution that would take the form of the model draft Resolution (Model Resolution XXX, protection of GSO FSS and GSO BSS networks from the aggregate equivalent power flux-density produced by multiple NGSO FSS systems in frequency bands where EPFD limits have been adopted) that is included in the regulatory Annex (Document USJTG4-9-11/4P2).

The model Resolution indicated above would establish a mechanism for addressing non-GSO coordination pursuant to No. S9.12 of the Radio Regulations, while ensuring that the aggregate levels of emissions into GSO FSS and GSO BSS networks are not exceeded. The following are elements of a suggested approach:

- Non-GSO FSS systems in bands where EPFD limits are in place after WRC-2000 would have their compliance with the EPFD single-entry limits verified by the BR during the coordination/notification stage of system implementation.
- After one non-GSO FSS system has been brought into use in these bands:
  - each successive non-GSO FSS system would have to complete coordination with all other non-GSO FSS systems pursuant to No. S9.12 of the Radio Regulations; and
  - in addition, the BR would have to verify that the simultaneous operation of the new non-GSO system and the non-GSO FSS systems that have previously been brought into use in a particular band, using parameters that reflect the agreement(s) reached in coordination, does not produce EPFD into GSO networks at levels in excess of the aggregate EPFD levels specified in Annex 1 of model Resolution XXX;
  - in coordinations between and among non-GSO FSS systems in bands where EPFD limits are in place after WRC-2000, administrations that have operating non-GSO FSS systems would have to make every possible effort to accommodate the new non-GSO FSS system entrant, and all involved administrations would be encouraged to use actual parameters to the greatest possible extent.
- ITU-R should be tasked with the responsibility to develop, before the next conference subsequent to WRC-2000, a software specification to enable it to perform the multiple-system verification that would be required under this approach.

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PROPOSED TEXT FOR SECTIONS 3.1.4.1, 3.1.4.2 AND 3.1.4.3 OF CHAPTER 3 OF THE CPM-99 REPORT REGARDING SHARING BETWEEN FS AND NON-GSO FSS SYSTEMS

Introduction

Chapter 3 of the CPM-99 Report is entitled "Non-GSO FSS issues (WRC-2000 agenda item 1.13)".

Section 3.1 is entitled "Review of power limits appearing in Articles S21 and S22 and identification of any appropriate revisions".

Section 3.1.4 is entitled "Sharing between non-GSO FSS systems and terrestrial and space science services in the bands 10.7 - 12.75 GHz, 12.75 - 13.25 GHz, 13.75 - 14.5 GHz, 17.3 - 18.4 GHz (Earth-to-space), 17.7 - 19.3 GHz (space-to-Earth), and 27.5 - 28.6 GHz".

Purpose

The purpose of this contribution is to propose draft text for Sections 3.1.4.1, 3.1.4.2 and 3.1.4.3 of the CPM-99 Report addressing sharing between FS and non-GSO FSS in the Ku- and Ka-bands. The proposed text is taken directly from the liaison to JTG 4-9-11 (Document 4-9-11/369) which was sent from the April 1999 meeting of WP 4-9S and has been based on Documents 4-9S/TEMP/92, 4-9S/TEMP/96, 4-9S/TEMP/91 and 4-9S/TEMP/105. Any proposed changes to the Document 4-9-11/369 text are indicated with revision marks.

Pfd limits applicable to non-GSO FSS satellites transmitting in the 10.7 - 12.75 GHz band

This section proposes CPM-99 text regarding sharing between FS receivers and satellite transmitters of non-GSO FSS systems operating in the bands 10.7 - 12.75 GHz.

3.1.4.1 Protection of fixed service systems from interference caused by non-GSO FSS space stations in bands covered by Article S21

3.1.4.1.1 Protection of fixed service systems in the 10.7 - 12.75 GHz band

(The text in this section is taken verbatim from Document 4-9-11/369, "Proposed CPM text for consideration in JTG 4-9-11 on pfd limits applicable to non-GSO FSS systems in the 10.7 - 12.75 GHz band" (Source: Document 4-9S/TEMP/92; Subject: Resolution 131 (WRC-97)). Any proposed changes to the WP 4-9S text are indicated with revision marks.)

a) Characteristics of the fixed service systems in the 10.7 - 12.75 GHz band

The FS characteristics to be used for the purpose of simulations in order to derive pfd limits in the 10.7 - 12.75 GHz are given in the following table:

Elevation angles	0 and 0.2°
Antenna height	0 metres
Antenna gain	45 and 49 dBi
Antenna pattern	Recommendation ITU-R F.1245
Latitudes	25, 45 and 60°
Gaseous attenuation	Recommendation ITU-R SF.1395
Feeder loss	3 dB~~Db~~
Polarization loss	Recommendation ITU-R F.1245 (NOTE 7)
Receiver thermal noise	-140 dB(W/MHz)

These characteristics are representative of a majority of links in that frequency range.

b) Fixed service protection criteria

The aggregate FS protection criteria in the 10.7 - 12.75 GHz range are given as follows in draft new Recommendation ITU-R F.[Document 9A/TEMP/65] to be submitted to 2000 Radiocommunication Assembly for approval:

- Maximum I/N = +20 dB
- Long-term interference:

  D_{ltEPO} or FDP (see Recommendation F.1108) of 10%,

  where $D_{ltEPO} = (0.89 \times \int_{10^{-6}}^{1} \frac{I(t)}{N} dt) \times 100\%$.

  D_{ltEPO} is the error performance objective degradation due to long-term interference.

  I(t)/N is interference to noise ratio that could be exceeded during no more than "t" fraction of any month time.

These aggregate FS interference criteria have been derived from considerations of the allowable degradation of error performance objective (EPO) due to interference from systems operating co-primary, on typical FS links using ATPC features.

c) Methodologies used to assess the adequacy of the limits to protect the fixed service

~~A p~~Pfd mask analysis has been used for assessing the adequacy of the pfd limits for the protection of the FS; the statistics of the aggregate power levels received at a FS station are calculated by applying pfd limits under consideration to each visible satellite of the non-GSO FSS constellation[1].

[1] Annex 1 of Recommendation ITU-R F.1108-2 provides guidance on the calculation of visibility statistics of space stations operating in circular non-GSO orbits as seen by a terrestrial station.

In the derivation of the pfd limits defined in ~~*recommends* 1~~section d), it was determined that if the calculated FDP results exceed the criteria of section 2 by no more than a few per cent, this does not mean that the FS links would actually be impaired. It must be noted that the pfd mask analysis is overly conservative in that it computes interference (both long term and short term) that exceeds what would be produced by an operating non-GSO FSS system. This is because the analysis assumes that all the visible satellites of the non-GSO FSS constellation radiate simultaneously the maximum pfd limit in the direction of the FS system under consideration, which is unrealistic. In addition, such an assumption does not take into account the patterns of real satellite antennas, or the restrictions that self-interference would impose on a non-GSO FSS system.

Calculations are made assuming that the FS receiver antenna is pointing in the direction of the worst-case azimuth for the non-GSO constellation under consideration, since in that pointing direction, the long-term and short-term power levels generated by the non-GSO constellation into the FS receivers are maximum.

Studies in other bands that have considered a more realistic modelling of a similar problem have produced results providing further evidence supporting that the pfd limits in ~~*recommends* 1~~ section d) are adequate. The method used takes into account some fundamental operational constraints of non-GSO FSS systems by using more realistic downlink models developed to generate pfd distribution profiles for a range of arrival angles which are used in place of the maximum-allowed pfd mask.

Given the methodology and assumptions used for evaluating the pfd limits, it can be assumed that the FS aggregate interference criteria given in [draft new] Recommendation ITU-R F. [Document 9A/TEMP/65], can be applied for each single non-GSO FSS constellation. These conclusions remain valid if the number of co-frequency non-homogeneous non-GSO FSS systems were in the range 3 to 5.

d) Results of studies relating to the review/revision of the power limits appearing in Article S21 in the 10.7 - 12.75 GHz band

The current RR Article **S21** per satellite pfd limits, as defined below and as discussed more fully in draft new Recommendation [4-9S/AI], are adequate for the protection of the FS in the 10.7 - 12.75 GHz band from aggregate interference from three assumed non-homogeneous, non-GSO FSS systems. Moreover, the contribution of GSO interference to the sharing has been shown as not being significant. Studies support and validate this conclusion. These results would remain valid if the number of non-GSO FSS systems were in the range 3 to 5.

- in the 10.7 - 11.7 GHz band:

  -126 dB(W/m^2/per 1 MHz) for $0° \le \delta < 5°$
  -126 +(δ-5)/2 dB(W/m^2/per 1 MHz) for $5° \le \delta < 25°$
  -116 dB(W/m^2/per 1 MHz) for $25° \le \delta < 90°$

  where δ is the angle of arrival above the horizontal plane.

- in the 11.7 - 12.75 GHz band:

  -124 dB(W/m^2/per 1 MHz) for $0° \le \delta < 5°$
  -124 +(δ-5)/2 dB(W/m^2/per 1 MHz) for $5° \le \delta < 25°$
  -114 dB(W/m^2/per 1 MHz) for $25° \le \delta < 90°$

  where δ is the angle of arrival above the horizontal plane.

Pfd limits applicable to non-GSO FSS satellites transmitting in the 17.7 - 19.3 GHz band

This section proposes CPM-99 text regarding sharing between FS receivers and satellite transmitters of non-GSO FSS systems operating in the bands 17.7 -19.3 GHz.

3.1.4.1.2 Protection of fixed service systems in the 17.7 - 19.3 GHz band

(The text in this section is taken verbatim from Document 4-9-11/369, "Proposed CPM text for consideration in JTG 4-9-11 on pfd limits applicable to non-GSO FSS systems in the 17.7 - 19.3 GHz band" (Source: Document 4-9S/TEMP/96; Subject: Resolution 131 (WRC-97)). Any proposed changes to the WP 4-9S text are indicated with revision marks.)

a) Characteristics of the fixed service systems in the 17.7 - 19.3 GHz band

The FS characteristics used for the evaluation of pfd limits for non-GSO FSS satellites in the 17.7 - 19.3 GHz band are given in the following table.

Elevation angles	0 and 2.2°
Antenna height	0 metres
Antenna gain	32, 38 and 48 dBi
Antenna pattern	Recommendation ITU-R F.1245
Latitudes	25, 45 and 60°
Gaseous attenuation	Recommendation ITU-R SF.1395
Feeder loss	3 dB
Polarization loss	Recommendation ITU-R F.1245 (NOTE 7)
Receiver thermal noise	-139 dB(W/MHz)

These characteristics are representative of a majority of links in that frequency range.

b) Fixed-service protection criteria in the 17.7 - 19.3 GHz band

The aggregate FS protection criteria in 17.7 - 19.3 GHz band are given as follows in draft new Recommendation ITU-R F.[Document 9A/TEMP/64] to be submitted to 2000 Radiocommunication Assembly for approval:

Long term: I/N = -10 dB not to be exceeded for more than 20% of the time

Short term: I/N = +14 dB not to be exceeded for more than 0.01% of the time

I/N = +18 dB not to be exceeded for more than 0.0003% of the time

Note that the short-term criteria were established to protect sensitive FS links.

c) Methodologies used to assess the adequacy of the limits to protect the fixed service in the 17.7 - 19.3 GHz band

~~p~~Pfd mask analysis has been used for assessing the adequacy of the pfd limits for the protection of the FS; the statistics of the theoretical aggregate power levels received at a FS station are calculated by applying pfd limits under consideration to each visible satellite of the non-GSO FSS constellation[2].

In the derivation of the pfd limits defined in ~~*recommends* 1~~section d), it was determined that if the calculated I/N results exceed the criteria of Section 3 by no more than a few dB for worst-case geometries, this does not mean that the FS links would actually be impaired. It must be noted that the pfd mask analysis is overly conservative in that it computes interference (both long term and short term) that exceeds what would be produced by an operating non-GSO FSS system. This is because the analysis assumes that all the visible satellites of the non-GSO FSS constellation radiate simultaneously the maximum pfd limit, in the direction of the FS system under consideration, which is unrealistic. In addition, such an assumption does not take into account the patterns of the real satellite antenna, the power limitations of each satellite or the restrictions that self-interference would impose on a non-GSO system.

Calculations are made assuming that the FS receiver antenna is pointing in the direction of the worst-case azimuth for the non-GSO constellation under consideration, since in that pointing direction, the long-term and short-term power levels generated by the non-GSO constellation into the FS receivers are maximum.

Studies that have considered a more realistic modelling of the problem have produced results providing further evidence supporting that the pfd limits in ~~*recommends* 1~~section d) are adequate. The method used takes into account some fundamental operational constraints of non-GSO FSS systems by using more realistic downlink models developed to generate pfd distribution profiles for a range of arrival angles which are used in place of the maximum-allowed pfd mask.

Given the methodology and assumptions used for evaluating the pfd limits, it can be assumed that the FS aggregate interference criteria given in draft new Recommendation ITU-R F.[9A/TEMP/64], can be applied for each single non-GSO FSS constellation. These conclusions remain valid if the number of co-frequency non-homogeneous non-GSO FSS systems were in the range 3 to 5.

d) Results of studies relating to the review/revision of the power limits appearing in Article S21 in the 17.7 - 19.3 GHz band

The following per satellite pfd limits (also described in draft new Recommendation SF.[4-9S/TEMP/94])* are adequate for the protection of the FS in the 17.7 - 19.3 GHz band from aggregate interference from three assumed non-homogeneous, non-GSO FSS systems. Moreover, the contribution of GSO interference to the sharing has been shown as not being significant. Studies support and validate this conclusion. These results would remain valid if the number of non-GSO FSS systems were in the range 3 to 5.

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[2] Annex 1 of Recommendation ITU-R F.1108 provides guidance on the calculation of visibility statistics of space stations operating in circular non-GSO orbits as seen by a terrestrial station.

* Submitted to RA-2000 for approval.

-115 - X	dB(W/m^2 per MHz) for $0° \leq \delta < 5°$
-115 - X +((10 + X)/20)(δ-5)	dB(W/m^2 per MHz) for $5° \leq \delta < 25°$
-105	dB(W/m^2 per MHz) for $25° \leq \delta < 90°$

where δ is the angle of arrival above the horizontal plane and X is defined as a function of the number of satellites in the non-GSO FSS constellation, n, as follows:

for $n \leq 50$	$X = 0$	(dB)
for $50 < n \leq 288$	$X = (5/119)(n - 50)$	(dB)
for $n > 288$	$X = (1/69)(n + 402)$	(dB)

The scaling function, X, was developed on the basis of non-GSO FSS constellations with 96, 288 and 840 satellites. Further simulations with different non-GSO FSS constellations comprising a wide range in the number of satellites (63, 126, 189, 252, and 504 satellites) and using the conservative pfd mask simulation method have confirmed the adequacy of this scaling function.

Extensive studies have provided technical justification that the pfd limits above are certainly adequate to protect the FS from aggregate interference from the satellites of multiple, co-frequency non-GSO FSS systems operating in the 17.7 - 19.3 GHz band. Therefore these pfd limits are acceptable in that they protect the FS without unduly constraining the development of non-GSO FSS networks.

Protection of non-GSO FSS satellite receivers from interference caused by FS transmitters

This section proposes CPM-99 text regarding sharing between FS transmitters and satellite receivers of non-GSO FSS systems operating in the bands identified by WRC-97 in Resolution 130.

3.1.4.2 Protection of non-GSO FSS space station receivers from interference caused by fixed service systems in the bands 12.75 - 13.25 GHz, 17.7 - 18.14 GHz, and 27.5 - 28.6 GHz

(The text in this section is taken verbatim from Document 4-9-11/369: Proposed CPM text (section 3.1.4.2) for consideration in JTG 4-9-11 sharing between the FS and non-GSO FSS space stations (Earth-to-space) (Source: Document 4-9S/TEMP/91; Subject: Resolution 130 (WRC-97)). Any proposed changes to the WP 4-9S text are indicated with revision marks.)

Studies have been undertaken to evaluate the interference from fixed service systems into non-GSO FSS space stations in the bands where the two services are allocated on a co-primary basis in the 12.75 - 18.14 GHz frequency range and in the 27.5 - 28.6 GHz band.

3.1.4.2.1 12.75 - 18.14 GHz frequency range

The studies were based on the characteristics of typical FS point-to-point systems and on the characteristics of the space stations of FSATMULTI-1B non-GSO FSS system. The study concluded that, even under pessimistic assumptions, the interference from FS systems into non-GSO FSS (earth-to-space) in the 12.75 - 18.14 GHz frequency range would be acceptable.

3.1.4.2.2 27.5 - 28.6 GHz band

The studies were based on the characteristics of typical FS point-to-multipoint systems and on the characteristics of the space stations of LEOSAT-1 non-GSO FSS system. One study has considered the interference from high deployment of FS subscribers terminals into the main beam and the near

side lobes of the non-GSO FSS satellite antenna. This study concluded that the interference levels would be acceptable since they are significantly lower than the generally agreed criterion. However, the study did not consider the aggregate impact of all transmitters located within the entire portion of the Earth visible to the satellite, the interference from a terminal's main beam into the side lobes of the satellite, or the interference between the FS hub transmitters using sectoral antennas into the non-GSO FSS satellite receiver. There was also concern expressed with the assumptions used in the study that might not be worst case in terms of transmit power levels or elevation angles. On this basis, further studies would be required before definitive conclusions can be reached.

It must also be noted that the current Radio Regulations allow higher e.i.r.p. values to be transmitted in this band, than the P-MP FS stations studied in this paper. Limits of 10 dBW on the transmit power and 55 dBW on the e.i.r.p. are specified in RR Article 21 and ITU-R SF.406, with no restriction placed on the bandwidth or elevation angle. Therefore, there may be a need to review the e.i.r.p. limits considering bandwidth and elevation angle, for FS transmitters operating in this band.

Sharing between non-GSO FSS earth stations and FS stations

This section proposes CPM-99 text regarding sharing between FS and earth stations of non-GSO FSS operating in the bands identified by WRC-97 in Resolution 130.

3.1.4.3 Sharing between non-GSO FSS earth stations and fixed service stations

(The text in this section is taken verbatim from Document 4-9-11/369: Draft element for inclusion in the report of CPM-99 (Source: Document 4-9S/TEMP/105; Subject: Resolution 130 (WRC-97)). Any proposed changes to the WP 4-9S text are indicated with revision marks.)

The deployment needs of viable FS and FSS services range from sparse, low density to increasingly higher density. This affects the sharing conditions in terms of coordination between fixed stations and FSS earth stations. At one extreme is the low-density deployment of both services, which facilitates sharing. At the other extreme is the high-density deployment of both services, which creates the most difficult sharing environment. In this instance, either one or both services may be excessively constrained or prevented from offering a viable service in the same geographical area.

In the 10 - 30 GHz range, the fixed service applications are rapidly evolving to support cellular and PCS infrastructures as well as direct access to business and residential subscribers. There are also proposals for high-density FSS earth station applications. Some administrations are considering the authorization of such systems using area-wide (blanket) licensing. Such licensing schemes lead to a requirement for new approaches in order to facilitate sharing.

The case of sharing between FS and large FSS earth stations can be ~~easily~~ handled through classical case-by-case coordination procedures which have already proved to work successfully. In the case of deployment of ubiquitous FSS terminals, in principle, the use of mitigation techniques by one or both services improves the ability of those services to share the same frequency bands. The feasibility of potential mitigation techniques and their relative effectiveness are currently being studied. This involves a wide range of technical, economic and regulatory trade-offs. Furthermore, it has been shown that as as the deployment density of either service increases, proposed interference mitigation techniques rapidly become ineffective. In cases where mitigation is insufficient or not practicable in those bands that are already or planned to be heavily used by the one type of service, possible solutions range from frequency separation to constraining the introduction of the other type of service to low-density, non-ubiquitous applications.

In summary, frequency sharing between FS and FSS in the same geographic area is difficult if either service deploys large numbers of stations. However, this is a national issue except in the vicinity of international borders, where coordination between administrations may be required.